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A MODEL FOR VISUAL ATTENTION(U) NORTHEASTERN UNIV
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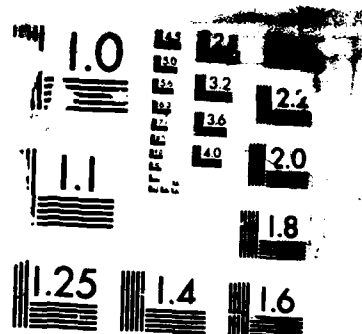
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<p>A model for shifts of human visual attention was developed and tested. The model predicts confusion in the perceived order of visually-presented items (RSVP paradigm) following a shift of visual attention to the location in which those items are presented. The model was confirmed over a range of presentation rates, and two types of visual characters (numerals and outline shapes). The function describing the attention shift does not vary as the spatial distance over which attention may be moved is varied, nor does it vary if the eyes shift or remain fixed when attention moves, so that the effect of attention seems rather to open a gate into short-term visual memory (independent of visual space), than to 'move' attention across visual space. This is compatible with the current model.</p>					
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Final Report for grant AFOSR-84- 8092
"A model for visual attention"

AFOSR-TN- 87 - 0399

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1. Purpose of research.

We studied visual attention with the attention-shift RSVP (rapid serial visual presentation) paradigm. In this paradigm, a human observer watches two streams of alphanumeric characters which appear, one after another (serially) to the same two locations on a display monitor. These locations lie one on each side of the central fixation point. The characters are presented rapidly (up to 13 characters/sec), but not so rapidly that they blur together. The task requires the observer to monitor the stream at the left for a target character. Having detected the target, he must shift attention to the stream at the right. The observer must then report the first four numerals that he can from the numeral stream.

In earlier work, it was found that observers reported numerals from the numeral stream in non-veridical orders. Typically, numerals reported as seen first were presented actually 400 msec after the target. Other numerals, presented both before and after this, were typically reported as being seen later in the stream. Despite many hours of practice with full feedback on each trial, observers were unable to overcome this illusion, a 'folding' of temporal order around the central (+400 msec) point. Since the numerals were presented too fast to be individually named, we concluded that this was a result of shifting attention on short-term visual (not verbal) memory (VSTM).

The purpose of the present work was to further develop and test a model for this effect.

1. The model.

In collaboration with George Sperling (New York University), who is also supported by AFOSR, a 'generalized attention gating model' (GAGM) was developed and tested during the grant period. This is a theoretical model from which we could derive an empirical model (the AGM) which had been developed before. Both models are fully described in Reeves and Sperling (1986). The essential idea is that attention operates to gate items into VSTM. A curve was derived which describes a rapid opening and slow closing of the attention gate. The order of items in VSTM (and thus in the observer's reports) is determined by the presentation times of the items, the amount of attention they receive while being gated into memory, and (in GAGM) a weighted integral of the latter quantity. The GAGM model describes the original data set, in which numeral rates and targets were varied, to a high degree of accuracy with few parameters.

2. The character set.

A prediction of the model is that only VSTM, not further encoding (e.g. into numeral names stored in long-term memory) is critical in determining report orders. In the grant period I tested this by developing a character set of ten un-named simple shapes.

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These shapes were distinguished by features whose positions corresponded well with the ten keys on a computer console key-pad. Thus, it was possible to report the items by shape, without ever needing further encoding of them. Data were collected with numeral streams and shape streams in alternate trial blocks. Results obtained with shapes were closely comparable to those for numeral reports (Reeves, 1987), supporting the prediction.

A second prediction of the model is that order should not be folded if attention is kept continuously on the numeral (or shape) stream. To test this, I turned off the letter stream and merely indicated when reports should start. The reports showed a somewhat faster "attention reaction time" (Sperling & Reeves, 1980), but no change in folding: order was just as likely to be inverted as before (Reeves, 1987). The reason, in retrospect, is simple: in order to prevent VSTM from being filled up with useless characters, attention to the numeral stream must be kept off, until the target arrives. Then, attention is turned on, with the consequences predicted by the GAGM model. Thus this version of the paradigm did not succeed in testing a critical model assumption. However, the finding of folded order in a single stream in RSVP is new.

A third prediction of the current model is that the attention shift should follow the same time course, controlled by the gating signal, no matter what the load on memory provided by the numeral stream which attention is being shifted. To test this, I required the observer to recall either 2, or 4, or 6 numerals on each trial. The same GAGM parameters derived, say, from the recall-4 trials, should also describe the data from the recall-2 and recall-6 trials. This has been found to be the case for the two observers run so far, but this work is not quite complete.

A fourth prediction is that gate-opening into short-term memory should be independent of the spatial positions of the streams. That is, attention in GAGM operates to turn on a gate at a specific (known) position, not to 'move' attention, in spot-light fashion, from one stream to the other. Earlier work at NYU (with Sperling and Weichselgartner) confirmed this prediction, but eye movements were not measured, which may be a problem as the felt tendency to move the eyes from one stream to the other seems to increase as the distance between the streams increases. I am currently repeating this work with an ISCAN eye-tracking system, bought by this grant. The necessary programming to integrate the eye-recordings with the display control has been accomplished, and one subject has been run on an extensive set of conditions. So far the earlier conclusion replicates.

A fifth prediction is that the effect of the attention shift (folding of order) should not depend on the presence or absence of eye-movements. This prediction, which again follows from the assumption of gate-opening, is in opposition to a plausible alternative: that folding arises because of the un-naturalness of moving attention without moving the eyes. In the studying this issue, I have found it easy to move attention with the eyes, or when the eyes are still, and in both cases folding occurs (two subjects). However, moving the attention from the letter stream to the numeral stream while simultaneously moving the eye in the opposite direction appears to be very difficult (perhaps impossible on most trials). Hence, one cannot conclude that eye movements and attention shifts are totally

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independent. It may be that moving the eyes in the prescribed way requires sufficient attention to disrupt the process which opens the attention gate. Work on this point is also on-going.

2. Attention and visual imagery.

In a different line of investigation, we have found during the grant period that instructions to imagine lines can profoundly disrupt vernier acuity, if the lines to be imagined are located (mentally) within a degree or so of the acuity target. This effect is independent of image orientation, and takes about 6 sec to die away (Lemley and Reeves, 1987). It is not due to peripheral factors (accommodation, pupil diameter, or eye movements), but represents a genuine perceptual interference (known generally as the 'Perky' effect).

We wondered whether this might be because the image distracted the observer's attention from the acuity target. However, images placed further into the periphery interfere very little (but seem to require as much attention as central ones); attention can be recalled to the target area within 200 msec, but the imagery effect takes 6 sec to die away; and imagery and attention have independent effects when both are jointly varied, and attention is manipulated by varying the number of target locations to which attention must be paid ('division'). Although these points seem conclusive, we did find an interaction when attention was manipulated in a different way; subjects had to pay attention to a small, winking, peripheral target light ('distraction'). In this case, attention only influenced acuity in the absence of imagery. We replicated this remarkable result at two levels of baseline accuracy, high and low. Work is currently progressing on this point.

PAPERS

Reeves A. and Sperling S. (1986) Attentional theory of order information in short-term visual memory. *Psychological Review*, 93, 180-206.

Reeves A. (1987) Attention and the order of items in short-term visual memory. *Psychological Research* (in the press).

Lemley C.R. and Reeves A. (1987) Visual imagery selectively reduces visual acuity. Accepted pending revision (*Perception*).

TALKS.

"The control of the perceived order of visual events by attention" at a symposium on visual attention and action, at the University of Bielefeld, Bielefeld, West Germany (July 19865)

Lemley C.R. and Reeves A. Visual acuity under visual imagery (1986). *Invest. Ophthalm. & Vis. Sci.*, Suppl. 27. (ARVO Abstract)



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